PATENT SPECIFICATION

DRAWINGS ATTACHED

Inventors: CLIFFORD RAYMOND SCHOFIELD and BRIAN MIERS BAILEY

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COMPLETE SPECIFICATION

Rotary Transmission System

We, THE ENGLISH ELECTRIC COMPANY LIMITED, of English Electric House, Strand, London, W.C.2., a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement: —

This invention is concerned with a rotary transmission system for transmitting a drive between a prime mover which requires an external drive for starting (that is to say, it is not capable of starting itself without the aid of an external drive) and an auxiliary machine which is normally driven by the prime mover but which can itself be made to operate as a motor.

According to this invention the rotary transmission system includes a variable-speed transmission unit allowing for stepless drive ratio control through which the auxiliary machine can drive the prime mover smoothly up to the starting speed, this first mode of transmission being via a unidirectional clutch which freewheels when the prime mover overruns its input drive upon starting, and including a second unidirection coupling which is arranged to freewheel during the first mode of transmission and which drives positively during a second mode of transmission in which the prime mover, having started and having overrun its starting input drive, drives the auxiliary machine via the second clutch and the variable speed transmission unit.

In the second mode of transmission the variable-speed transmission unit can be controlled to vary the speed at which the auxiliary machine is driven. The drive ratio of the transmission unit may, for example, be controlled by a governor or the equivalent to maintain the speed of the auxiliary machine substantially constant, regardless of speed variations of the prime mover.

This invention is particularly applicable to the engine and generator system of an aircraft, the engine and generator serving respectively as the prime mover and auxiliary machine. During the first mode of transmission, for starting the aircraft engine, the generator is operated as a motor and is connected to an external source of electrical power. After the engine has started, the external source of electrical power is disconnected and the generator is driven by the engine and functions in its usual manner to generate the necessary electrical power for the aircraft. The generator preferably has an a.c. output and runs as a synchronous motor when serving as a starter.

In a preferred construction the transmission system includes a planetary gear train preferably comprising three elements, namely a sun gear wheel, a coaxial annular gear wheel surrounding the sun gear wheel, and a planetary gear wheel (or set of planetary wheels) meshing with both other gear wheels and bodily rotatable about the axis of the other gear wheels. One of the three elements is coupled to the variable-speed transmission unit input (that is to say, the input during normal operation when the engine is driving the generator) and is also coupled via the second unidirectional coupling to the engine; a second element is coupled to the engine via the first unidirectional coupling; and the third element is coupled to the generator, which is also coupled to the output of the variable-speed transmission unit.

Two examples of transmission-systems according to this invention are shown in the accompanying drawings. In these drawings: —

Fig. 1 is a somewhat diagrammatic view of one system;

Fig. 2 is a diagrammatic perspective of a second system;

Fig. 3 is a fragmentary section on the axis of the system shown in Fig. 1;

Fig. 4 is a graph showing the relative speeds of the different components during starting and subsequently.

The transmission system shown in Fig. 1 forms the driving connection between a prime mover which is an engine 10 and an auxiliary machine which is an a.c. generator 12, and the transmission system includes a variable-speed transmission unit 14 which is preferably in the form of a rolling frictional drive gear. In addition there are two unidirectional couplings 16A and 16B which serve respectively as the first and second couplings according to this invention; both couplings are sprag clutches, but other forms of unidirection couplings may alternatively be used.

During the first mode of transmission, in which the generator 12 is run as a synchronous motor, the drive from the generator to the engine 10 is transmitted via a planetary gear train having three elements, namely a sun gear wheel 18, an annular gear wheel 20 coaxially surrounding the sun 18, and a set of planetary gears 22 mounted on a planetary carrier 24 by which the planetary gears can be bodily rotated about the axis of the other gears. The sun gear wheel 18 is mounted on a hollow shaft 26 which is the input shaft of the variable unit 14 while the engine is driving the generator.

The annular gear wheel 20 is connected to the engine 10 via the first sprag clutch 16A, which is so arranged that the gear wheel 20 can drive the engine shaft 28 only in a clockwise direction.

The planetary carrier 24 is connected to a generator shaft 30 via a lay-shaft 32 and an idler gear wheel 34. As shown in Fig. 1, a gear wheel 36 at one end of the lay-shaft 32 meshes with a gear wheel 38 formed on the planetary carrier 24, and at the other end of the lay-shaft, there is a gear wheel 40 which meshes with the idler gear 34, which in turn meshes with a gear 42 on the shaft 30. The shaft 30 also serves as, or is connected to, the output from the variable unit 14 (that is to say, the output while the generator is being driven by the engine).

During the first mode of transmission the planetary carrier 24 is driven by the generator so as to rotate the planetary gears 22 bodily about the centre axis in a clockwise direction. This tends to transmit a drive also to the annular gear wheel 20, but the tendency for the wheel 20 to rotate is reduced by rotation of the sun wheel 18. The speed output from the variable unit 14 at the shaft 26 is in fact arranged initially to be high enough to prevent any resultant rotation of the annular gear wheel 20. In order to run the engine up to speed, the speed output of the unit 14 is gradually reduced, with the result that the annular wheel 20 runs in a clockwise direction at an ever-increasing speed. During this mode of transmission, the clutch 16B freewheels because of the arrangement of the sprags which permit the shaft 26 to drive the shaft 28 only in an anti-clockwise direction (Similarly the shaft 28 can drive the shaft 26 through the sprag clutch only in a clockwise direction).

When the engine starts so as to run under its own power, it overruns the annular gear 20 (being permitted to do so by the arrangement of the clutch 16A) and a drive is then transmitted from the engine shaft 28 via the clutch 16B and the variable unit 14 to the generator 12. During this second mode of transmission, the lay-shaft 32 and its associated gears turn idly, and the speed of the generator shaft 30 can be adjusted by varying the drive ratio of variable unit 14. As has already been explained, the variable unit 14 may be used to provide an automatically controlled drive ratio in order to drive the generator at a substantially constant speed, regardless of speed variations of the engine at different times.

The system shown in Fig. 2 is basically the same as that shown in Fig. 1 and similar parts are identified by similar reference numerals as in Fig. 1. The difference is that, instead of the drive from the generator to the planetary carrier being transmitted by the lay-shaft 32, the drive in Fig. 2 is transmitted via a number of idler gears 50 which are mounted on fixed axes on a stationary member 52 and which mesh with a centre gear 54 on a shaft 56 which forms an extension of a shaft 58 connecting the generator 12 to the variable unit 14. The output from the variable unit, when the generator is operating as a motor to drive the engine, is via a hollow drum 70 which is connected to the sun gear wheel 18 of an epicyclic gear which operates in the same manner as the epicycylic gear in Fig. 1.

Fig. 2 shows that the variable-speed transmission unit is in the form of a Perbury gear, i.e. a rolling frictional drive gear having two outer torus discs 60 which are urged towards one another (by means not shown) to provide a frictional driving engagement by which a drive is transmitted between the discs 60 and a centre torus disc 62 by rollers 64. The speed ratio is varied by varying the angle of tilt of the rollers 64 with respect to the axis of the unit. As shown in Fig. 2, the rollers engage the centre torus disc 62 at a radius greater than that at which they engage the outer torus discs 60, so that the discs 60 rotate at a greater speed than the disc 62. When the rollers are tilted in the opposite sense, the converse applies. This will be explained more fully with reference to Fig. 3.

Fig. 3 shows in detail how the transmission system of Fig. 1 is arranged. Similar parts are identified by the same reference numerals as in Fig. 1.

It will be seen in particular, that the input shaft 26 of the variable unit is connected to a drum 70 which is splined to the periphery of the inner torus disc 62. This enables the torus disc 62 to move axially along shaft 30 to allow the outer torus discs to press evenly on the rollers 64.

One outer torus disc 60A is fixed to the shaft 30, while the second outer disc 60B is axially moveable along the shaft 30 (having a spline connected with the shaft 30) and is surrounded by a short cylinder 72 having an end portion 74 which defines with the disc 60B a fluid space 76 into which pressurised fluid is injected to produce the necesary axial load on the disc 60B. This axial load produces the necessary driving reaction between the rollers and the torus discs. The hollow shaft 26 surrounds part of the shaft 28, which is connected to the engine as shown in Fig. 1.

The shaft 28 is supported by a needle roller bearing 86 and ordinary bearing 82 respectively in the hollow shaft and casing member 84; in addition there are four roller bearings 80 for support adjacent to the sprag clutches 16A and 16B. The casing member 84 is secured to a main casing 87 which houses the variable unit and in which the lay-shaft 32 and various other gears are supported in roller bearings.

In order to start the engine, the rollers 64 of the variable unit are initially tilted in the opposite sense to that shown in Fig. 3 (as shown in broken outline) to give the maximum output speed to the shaft 26. The speed of the shaft 26 is initially such that the annular gear 20, and consequently also the shaft 28, are stationary while the generator rotates as a motor at synchronous speed. The output speed of the variable unit is then gradually reduced by bringing the rollers 64 gradually into line with the axis of the variable unit, and during the final stages of the starting operation the rollers move towards the inclination shown in Fig. 3. That is to say, the variable unit initially transmits a stepped-up speed from the shaft 30 to the shaft 26, and this speed ratio is gradually reduced and is finally reversed by an ever-increasing amount. During this first mode of transmission, the sprag clutch 16B free-wheels, as has already been explained, the drive being via the sprag clutch 16A. Upon starting, the engine overruns the annular gear wheel 20 and transmits a direct drive to the shaft 26 of the variable unit via the sprag clutch 16B. At this stage, the variable unit rollers 64 are inclined in the sense shown in Fig. 3 and thus step up the speed from the shaft 26 to the shaft 30. This stepping up of the speed by the variable unit is required at this stage because the engine speed is still lower than the required speed of the generator. Then as the engine speed increases, the rollers 64 of the variable unit are gradually brought closer to the state in which they are parallel to the axis of the shaft 30. During further operation the speed of the generator can be kept constant by adjusting the tilt of the variable unit rollers in any known manner to compensate for speed changes of the engine.

An example ofa suitable variable unit is described in our patent application No. 10574/67 (Serial No. 1,146,323).

Fig. 4 shows how the speeds of the different components vary during starting and subsequently. It will be seen that in this particular example, the speed of the shaft 26 of the variable unit (identified as speed N_p) is initially 14,000 r.p.m., while the engine speed (N_e) is zero. The generator speed, both during normal operation and during reverse operation as a motor, is 8,000 r.p.m. The supply of electrical power to the generator is arranged to cut out at about 3,100 r.p.m., at which stage, the engine has started and proceeds to run under its own power. The minimum idling of speed of the engine is 4,000 r.p.m. and from this speed to a speed of 8,000 r.p.m., the variable unit is required to compensate for engine speed variations to provide a constant output speed to the generator of 8,000 r.p.m. The overrunning of the annular gear wheel 20 by the engine shaft 28, with the consequent disengagement of the sprag clutch 16A, occurs somewhere between the speeds of 3,100 r.p.m. and 4,000 r.p.m. and at the same moment, the sprag clutch 16B automatically takes up the drive direct from the engine to the variable unit.

By varying the drive ratio of the variable unit, the generator speed can be kept at 8,000 r.p.m. regardless of the speed of the engine, which may vary betwen 4,000 r.p.m. and about 8,000 r.p.m. (or slightly above 8,000 r.p.m.).

WHAT WE CLAIM IS:—

1. A rotary transmission for transmitting a drive between a prime mover which requires an external drive for starting, and an auxiliary machine which is intended normally to be driven by the prime mover but which can itself be made to operate as a motor, the transmission system having a variable-speed transmission unit allowing for stepless drive ratio control through which the auxiliary machine can drive the prime mover smoothly up to the starting speed, this first mode of transmission being via a unidirectional clutch which freewheels when the prime mover overruns its input drive upon starting, and including a second unidirectional coupling which is arranged to freewheel during the first mode of transmission and which drives positively during a second mode of transmission in

which the prime mover, having started and having overrun its starting input drive, drives the auxiliary machine via the second clutch and the variable-speed transmission unit.

2. A rotary transmission according to claim 1 including a planetary gear train through which the auxiliary machine drives the prime mover during starting, one element of the planetary gear being coupled to the output of the variable-speed transmission unit during starting, while a second element is coupled to the input of the variable-speed transmission unit, a third element of the planetary gear train being coupled to the prime mover.

3. A rotary transmission according to claim 2 in which the planetary gear train comprises three elements, namely a sun gear wheel, a co-axial annular gear wheel surrounding the sun gear wheel, and a planetary gear wheel meshing with both other gear wheels and bodily rotatable about the axis of the other gear coupled to the variable -speed transmission unit input and being also coupled via the second unidirectional coupling to the prime mover, a second element being coupled to the prime mover via the first unidirectional coupling, and a third element being coupled to the auxiliary machine, which is also coupled to the output of the variable-speed transmission unit.

4. A rotary transmission according to any one of claims 1 to 3 in which the unidirectional couplings are sprag clutches.

5. An aircraft engine and generator coupled by a transmission according to any one of claims 1 to 4, the generator being capable of running as an electric motor for starting the engine.

6. A rotary transmission according to claim 1 and substantially as described with reference to the accompanying drawings.

S. A. GEORGE,
Chartered Patent Agent.

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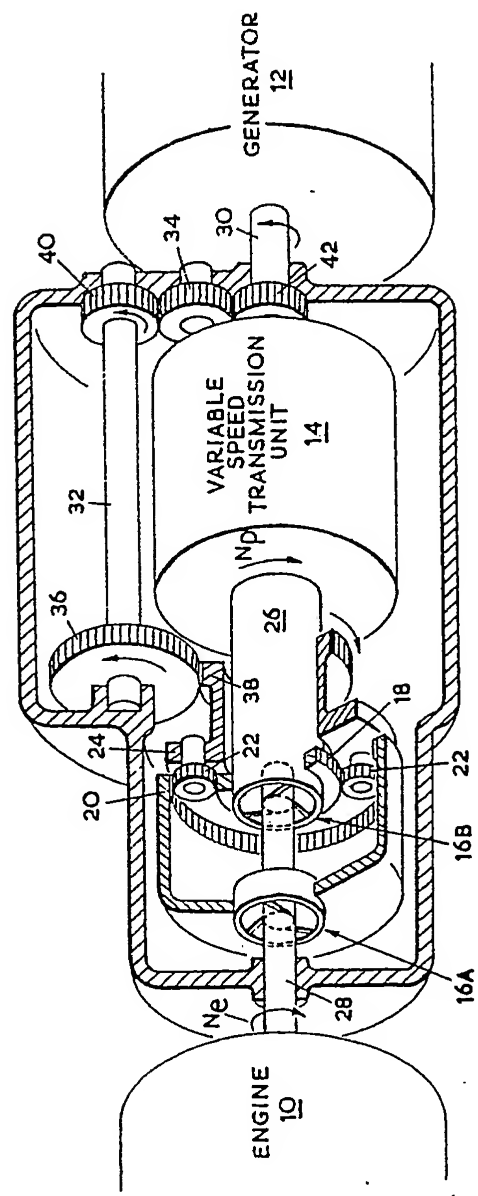
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16B
16A
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FIG.1

1199145 COMPLETE SPECIFICATION

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Sheet 2

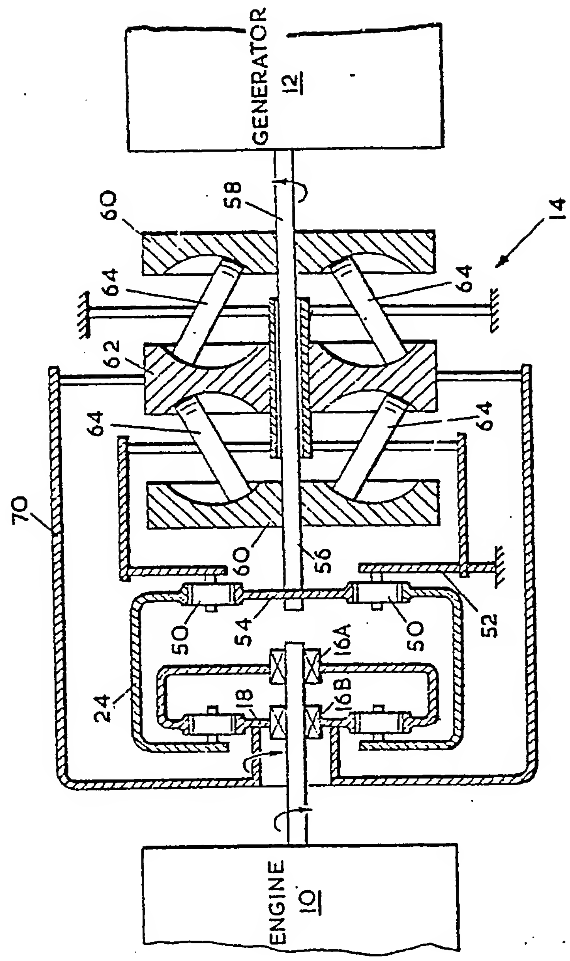

FIG.2

1190145 COMPLETE SPECIFICATION

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Sheet 3

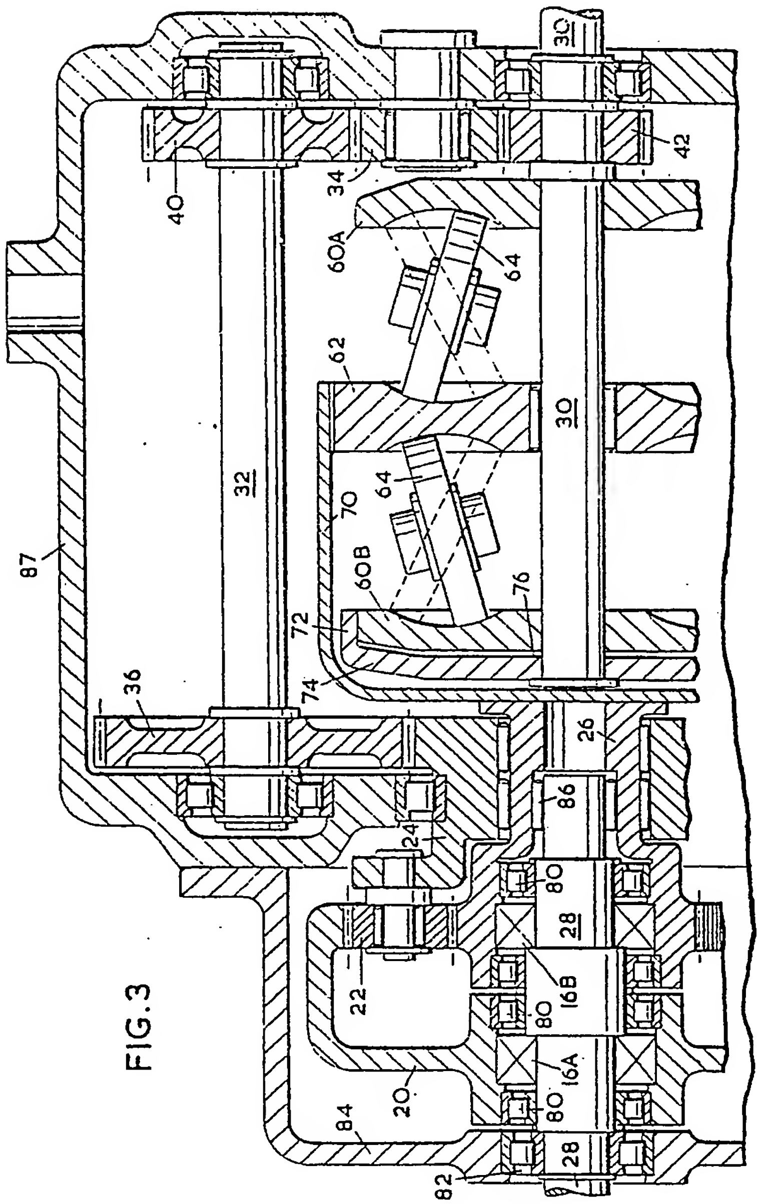
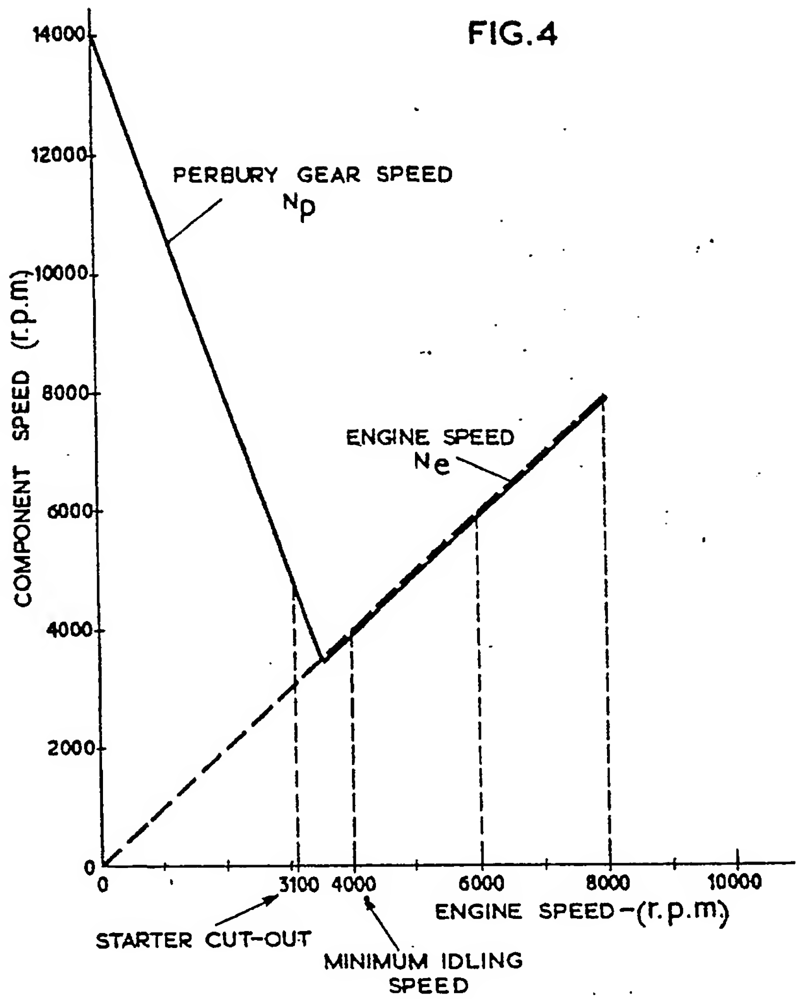


FIG.3

FIG. 4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ENGINE SPEED –(r.p.m)
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MINIMUM IDLING SPEED